Evaluation of Tanks 241-B-203 and 241-B-204 Level Data and In-Tank Video Inspections

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ACRONYMS

BBI	Best Basis Inventory
cfm	cubic feet per minute
DST	double-shell tank
HWS	Hanford Weather Station
HLAN	Hanford Local Area Network
HSIHD	Hanford Sitewide Industrial Hygiene Database
in.	inches
ILL	interstitial liquid level
IS	interim stabilization
kgal	thousand gallons
LOW	liquid observation well
RH	relative humidity
SL	surface level
SST	single-shell tank
TWINS	Tank Waste Information Network System
VOC	volatile organic compound
yr	year

1.0　Summary

This report documents level decrease evaluations for single-shell tanks (SST) 241-B-203 (B-203) and B-204. The evaluations show the liquid loss rate for both tanks can be explained by evaporation, there is no evidence indicating either of the tanks is actively leaking based upon the parameters used for estimating the liquid loss rate and evaporation rate.

These two SSTs with decreasing waste surface level (SL) data trends were recommended for level decrease evaluation in Letter, WRPS-1301005, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Level Decrease Evaluation Plan to The U.S. Department of Energy, Office of River Protection*, March 18, 2013, C. A. Simpson, Washington River Protection Solutions LLC, to S. E. Bechtol, U.S. Department of Energy.

Surface level data alone are inadequate to determine if a tank is leaking unless the gauge plummet is resting on liquid. Tanks B-203 and B-204 are among the few SSTs with 100% liquid surfaces.

Both tanks are designated Assumed Leakers in HNF-EP-0182, *Waste Status Summary Report for Month Ending April 30, 2013*, Revision 301.

2.0　Introduction

During the summer of 2012 SL and interstitial liquid level (ILL) plots were prepared for all 149 single-shell tanks (SST). Linear trendlines were drawn through the SL and ILL data points for each tank to provide an estimate of the SL or ILL long term change rates. Linear trendlines are of the form y = mx +b, with m being the slope of the line. Positive values of m mean the level is increasing and negative values mean it is decreasing.

An evaluation plan for SSTs with increasing SLs or ILLs was issued September 13, 2012 as an attachment to WRPS-1203139 R1, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Suspect Intrusion Evaluation Plan to The U.S. Department of Energy, Office of River Protection.* Concurrently with development and release of this plan, a second evaluation plan was drafted for SSTs with decreasing level data. This level decrease plan was issued on March 18, 2013 with WRPS-1301005.

Note: WRPS-1301005 has since been released as RPP-PLAN-55113, 2013, *March 2013 Single-Shell Tank Waste Level Decrease Evaluation Plan,* Revision 1, and is referred to by this number in the remainder of this document.

RPP-PLAN-55113, Rev 1, listed 83 SSTs with a decreasing ILL or SL. These tanks were screened down to a list of 20 recommended in RPP-PLAN-55113, Rev 1, for further level decrease evaluation.

The level decrease plan in RPP-PLAN-55113, Rev 1, committed to perform an initial evaluation for each of the 20 tanks that includes:

- Review of tank conditions.
- Evaporation estimates.
- Analysis of other conditions [e.g., long term response to interim stabilization (IS) or liquid observation well (LOW) installations, equipment calibrations or repairs] that could explain level decreases.

Following initial evaluation the 20 tanks were to be sorted into:

- Tanks for which the level decrease can be readily explained without further investigation, and,
- Tanks for which field investigations are needed to better understand the cause of the level decrease:
  - In-tank videos
  - Drywell logging
  - Other (as applicable)

The following results were to be documented:

- Initial evaluations
- Field investigations
- Determine if results warrant evaluation of any of the additional SSTs with negative SL or ILL trends not included in the list of 20

An announcement was made on February 15, 2013 that tank 241-T-111 (T-111) was leaking. On February 22, 2013 an additional five tanks with level decreases were announced. The level decreases for all six tanks were interpreted as leaks. As a result of the February 22, 2013 announcement the planned 20 tank evaluation was divided into 5 reports:

- T-111 (RPP-RPT-54964)
- T-203 and T-204 (RPP-RPT-55264)
- B-203 and B-204 (RPP-RPT-55265) – this report
- TY-105 (RPP-RPT-55263)
- Remaining 14 tanks (RPP-RPT-54981)

Each of the first four evaluations will include, for each tank:

- Review of tank conditions
- Evaporation estimates
- Analysis of other conditions
- Results of in-tank videos
- Conclusions

The fifth evaluation includes:

- Review of tank conditions for each tank
- Evaporation estimates for each tank
- Analysis of other conditions for each tank
- Conclusions for each tank
- An appendix providing evaporation rate vs. relative humidity plots and estimated headspace relative humidity for all 20 tanks
- An appendix providing the estimated heat generation rates for all 20 tanks

This report is the evaluation for tanks B-203 and B-204.

Table 1 provides the SL trendline decrease rates for tanks B-203 and B-204. Column 3 provides the decrease rates given in RPP-PLAN-55113, Rev. 1. These values were based upon SL plots with data current as of October-November 2012. Column 5 provides the updated SL decrease rates used in this document.

Table 1 Waste Surface Level Decrease Trends for Tanks B-203 and B-204

1	2	3	4	5
Tank	**Values from RPP-PLAN-55113 Rev. 1**		**Updated Values for RPP-RPT-55265**	
	ILL Change Rate (in./yr)	**SL Change Rate (in./yr)**	**ILL Change Rate (in./yr)**	**SL Change Rate (in./yr)**
B-203	No LOW	-0.075	No LOW	-0.072
B-204	No LOW	-0.070	No LOW	-0.069

3.0 Discussion

3.1 Selection of Tanks for Level Decrease Evaluation

Tanks were included on the list of 83 tanks in RPP-PLAN-55113, Rev 1 Appendix A, Table A-1, based upon their ILL and/or SL data change rate. All tanks with a change rate <0.001 in./yr were included. The basis for selection of tanks B-203 and B-204 for evaluation is described in that document, as well as the basis for the level change values in Column 3 of Table 1.

3.2 Updating of Tank Level Data Change Rates

The updated level data change rates in Column 5 of Table 1 are based upon linear trendlines drawn through the SL data points for each tank for as far back as a reasonable linear rate can be established.

The SL data change rates in Column 5 of Table 1 were estimated by:

- Downloading SL data from the Tank Waste Information Network System (TWINS - https://twins.labworks.org/twinsdata/Forms/About.aspx) database from January 1, 1990 to the present. The data back to 1980 is also included for some plots to show longer term trends.
- Plotting the results in Excel®. The following level data change plots were made for each tank:
  - A plot showing the SL raw data for the tank. The raw data is exactly as retrieved from TWINS with no adjustments for data correction. The y-axis is shown as approximately the same height as the full depth of the tank, to give the reader an indication of the relative rate of change for the tank SL.
  - A plot of the raw SL data, with the y-axis significantly expanded so that recent changes in the SL with time can be discerned.
- The expanded raw data plots were then reviewed for problems which could result in incorrect data interpretation. These include:
  - Repair or replacement of level gauge
  - Recalibration of level gauge resulting in different baseline depth value
  - Changing of zero value for tank reference level (i.e., changing from bottom of knuckle to tank centerline bottom)

For the purpose of data evaluation in this document a linear regression line provides an acceptable data change rate. The trendline formula is shown on the expanded y-axis plots, with the conversion factor to convert the trendline slope to a level data change rate in inches per year.

The final SL data change rates based upon the plot trendlines are given in Column 5 of Table 1. The plots for each tank are given in the tank evaluation section for the tank.

3.3 Volumetric Change Rates

The level change rates in Column 5 of Table 1 are converted to a volumetric change rate to assess the potential for a tank to be leaking. Estimation of a volumetric level change rate for any 200-series tank is based upon the following equation:

$$volumetric\ change\ rate = LCR\ in./yr \times 196\ \frac{gal}{in.} \times (FSL + (1 - FSL) \times \sigma)$$

where:

> LCR = level change rate in inches/yr
> FSL = fraction of waste surface that is liquid
> σ = waste porosity

Tanks B-203 and B-204 have 100% liquid surfaces, as determined by in-tank videos. The fraction of waste surface that is liquid for each tank is thus 1.0.

The waste porosity is irrelevant for tanks B-203 and B-204 because of the 100% liquid surface

Therefore, the volumetric change rate equation reduces to:

$$volumetric\ change\ rate = LCR\ in./yr \times 196\ \frac{gal}{in.}$$

3.4   Data Analysis

Changes in the SL data do not necessarily mean the SL is changing. Analysis of the data is necessary to interpret what is occurring. Factors that could cause changes in the surveillance data are listed in Table 2.

Table 2 Factors Causing Changes in Surface Level Data

	Factor
1	ILL increase and/or SL decrease due to consolidation/slumping of waste into pores.
2	Gas generation and entrapment within the waste causing level increase.
3	Release of retained gas entrapped within the waste causing a level decrease.
4	Conscious liquid additions to the tanks such as core sampling drill string flushes, core sampling head fluid additions, level gauges flushes, water lancing of equipment during installation, grab sample flushes.
5	Chemical changes within the waste.
6	ILL not at equilibrium following LOW installation or saltwell pumping (ILL only).
7	Level gauge plummet resting on uneven solid surface, (plummet rests on different spot when raised and lowered, or surface resistance changes), gauge maintenance or calibration problems, changing of tank reference location for zero level (SL only).
8	Water intrusion for level data increase.
9	Evaporation for level data decrease.
10	Tank leak for level data decrease.

The volumetric change rate is not necessarily a liquid volume change rate. The volumetric change rate is the sum of:

- Liquid addition to and/or removal from the tank
- Retained gas growth in and/or release from the tank
- Loss of gas due to porosity decrease
- Waste density change due to chemical changes

The tank volumetric change rate is equal to the net effect of intrusion, evaporation, leaks, and all other factors:

$$volumetric\ change\ rate = intrusion\ rate + evaporation\ rate + leak\ rate + \Sigma\ other$$

The intrusion rate, Factor 8, is positive or zero, the evaporation rate and leak rate, Factors 9 and 10, are negative or zero, and [Σ other] is equal to the net impact of Factors 1 through 5 in Table 2 and may be either positive or negative.

Factor 6 is irrelevant because there is no LOW in tanks B-203 or B-204.

Factor 7 is an assessment based upon review of the SL data plot trend and the data. If the plummet is resting on liquid or a reasonably flat solid surface, data changes can be assumed to represent changes in the waste surface. However, if the plummet is resting against debris in the tank or is perched on the edge of a crack or clump of waste such that data will be inconsistent, the data changes cannot be assumed to represent changes in the waste surface. In addition, some tanks had problems with the level gauge operation that resulted in misleading data trends, this became evident when the level gauge maintenance history was reviewed.

Rearranging the volumetric change rate equation:

$$leak\ rate = volumetric\ change\ rate - intrusion\ rate - evaporation\ rate - \Sigma\ other$$

or:

$$intrusion\ rate = volumetric\ change\ rate - leak\ rate - evaporation\ rate - \Sigma\ other$$

The volumetric change rate and the evaporation rate can be estimated from available data, and a value for [Σ other] assumed following a review of the available information. The net effect of the leak rate and intrusion rate can then be roughly estimated. It cannot be shown from SL data alone what a leak rate (or an intrusion rate) is for a tank without making assumptions as to the other variables in the equation. If the intrusion rate calculates to, e.g., (10 gal/yr + leak rate), this could mean there is a 10 gal/yr intrusion rate if the leak rate is zero, or a 30 gal/yr intrusion rate masking a -20 gal/yr leak rate, or any combination of intrusion plus leak rate that sums to a net 10 gal/yr. Data analysis cannot give separate values for a leak rate (or intrusion rate) but it can provide a degree of confidence as to what is probably occurring.

Data analysis is provided in the tank evaluation section for each tank.

4.0   Tank Evaluations

Each of the evaluations is divided up into the following subsections:

Tank Summary - Provides a short summary of the tank history and lists the Best Basis Inventory (BBI) tank waste volumes from a TWINS query on September 25, 2012.

Liquid Volume Change Rate – Converts the in./yr level change rates in Column 5 of Table 1 to gal/yr.

Data Analysis - Each tank data analysis uses the equation from Section 3.4:

$$volumetric\ change\ rate = intrusion\ rate + evaporation\ rate + leak\ rate + \Sigma\ other$$

where [Σ other] equals the net impact of:

- Waste subsidence
- Gas generation, entrapment, and release within the waste causing level increase or decrease
- Conscious liquid additions to the tanks such as core sampling drill string or grab sample bottle flushes, core sampling head fluid additions, level gauges flushes, water lancing of equipment during installation
- Chemical changes within the waste

Data analysis passes through the following steps for each tank:

- Estimation of a value for [Σ other]
- Estimation of a value for a potential intrusion rate
- Evaluation of whether changes in the SL data represent actual movement of the waste surface.

The first part of [Σ other] is the effect of waste subsidence.

The second part of [Σ other] is the effect of retained gas on the level change. The volume of retained gas in a tank is unknown, but the relative volume can sometimes be inferred from combined plots of the liquid level and the inverse of atmospheric pressure vs. time. If retained gas is present an increase in the atmospheric pressure may result in a decrease in the liquid level as the gas bubbles are compressed, and a decrease in the pressure will result in an increase in the liquid level. Predominantly sludge tanks do not have a rigid waste matrix and show far less response to atmospheric pressure than saltcake tanks. Tank SL data plots also show far less response to atmospheric pressure than ILL data. Plots of liquid level vs. the inverse of the barometric pressure are not provided for tanks B-203 and B-204 since they provide no useful information.

Conscious liquid additions make up the third part of [Σ other].

The last portion of [Σ other] is chemical change which may be occurring in the tanks over time.

A value is provided for [Σ other] consisting of four entries: The first entry is either 0 or PCE (for porosity change effect), the second entry is either 0 or RGG (for retained gas growth), the third is a numerical value to account for annual liquid addition to a tank, and the last is either 0 or WCE (for waste change effect).

In-Tank Video Results – In-tank videos were obtained for tanks B-203 and B-204. A description is provided of the waste surface, how the Enraf plummet is sitting, and any visible evidence of intrusion into the tank.

Evaporation Estimate - Estimating a tank evaporation rate without having equipment on each tank to measure all the conditions requires knowledge or estimation of:

- the temperature and water vapor content of the air entering a tank
- the temperature and water vapor content of the air leaving the tank
- the effective flow rate of air through the tank, and,
- accounting for condensation of water vapor from exiting air that returns to the tank.

The evaporation estimate methodology is described in RPP-RPT-54981, Rev 0, Appendix A. A summary of the evaporation estimate results are provided in the Evaporation Estimate section of each evaluation.

Tank Heat Generation Rate - The energy to evaporate water from a tank comes from two sources:

- latent heat of the waste, surrounding soil, and air passing through the tank, and,
- heat generated within the waste by radioactive decay

An estimate of the heat generation rate for each tank is provided based upon the radionuclide content.

Tank Leak Potential This subsection summarizes the information from the previous subsections.

Each evaluation has a summary plot that provides evaporation, relative humidity, and liquid loss information to assess the potential for the tank to be leaking. Each of these plots contains:

- A blue line showing the estimated evaporation rate as a function of the relative humidity (RH) in the air leaving the tank headspace.
- A black vertical line for the estimated tank headspace RH for each tank. The basis for the estimate of the RH For tanks B-203 and B-204 is provided in RPP-RPT-54981, Rev 0, Appendix A, Section A.6.
- A black horizontal dashed line for the estimate of the liquid loss rate.

Where the black line crosses the blue line is the estimated evaporation rate for a tank, based upon the conditions assumed for the tank conditions.

If the liquid loss rate is below the estimated tank evaporation rate for the conditions assumed for a tank, there is no evidence the tank is leaking. Tanks B-203 and B-204 are unique among SSTs in that they have a 100% liquid surface. This means the liquid loss rate is known fairly accurately, since waste porosity is irrelevant and fraction of the surface that is liquid is known.

The evaporation rate, liquid change rate, and headspace relative humidity values presented for each tank are used together to provide a basis to determine the potential for a tank to be actively leaking.

Conclusion The final subsection summarizes the information in the previous subsections and gives a conclusion as to whether there is evidence the tank is leaking or not.

4.1   Tank B-203

4.1.1   Tank Summary

Tank B-203 was put into service in 1948 when it received 224 waste (plutonium purification cycle waste) from B-Plant. It was filled by 1952, but is reported to have received occasional flush solution transfers up to 1963. Most of the supernate was transferred out to an SST in 1974. It was declared an assumed leaker in 1983 and interim stabilization was documented as complete in 1984 (RPP-RPT-42957, *2009 Auto TCR for Tank 241-B-203,* Revision 0, HNF-EP-0182, Revision 301). Per a TWINS query on September 25, 2012 the tank contains 49.7 kgal sludge and 0.5 kgal supernatant liquid.

Figure 1 shows the raw SL data for tank B-203 from January 1, 1990. Figure 2 is a plot of the data used for calculation of the -0.075 in./yr trendline slope for the Enraf portion of the data used for RPP-RPT-55113, Rev 1, with an expanded y-axis so the SL data changes can be seen. The SL shows a fairly constant decrease since before 1990. The SL data for Figure 1 and Figure 2 are from a TWINS tank surface level data download on February 15, 2013. Figure 3 is an updated plot showing the latest data included for this document. The slope of the decrease line is essentially the same at -0.072 in./yr. The SL data for Figure 3 are from a TWINS tank surface level data download on September 4, 2013.

There is no LOW in the tank.

Figure 4 is a plot from 1980 with the manual tape data (adjusted by having 6 inches added to it to account for the reference level change on June 22, 2000) and the ENRAF data combined. This plot indicates the decrease rate in tank B-203 has been fairly consistent for over 25 years.

4.1.2   Liquid Change Rate Estimation

The waste porosity is not a factor since the tank has a 100% liquid surface per the in-tank video(s).

The estimated tank B-203 liquid change rate is:

$$Tank\ B-203\ estimated\ liquid\ change\ rate = -0.072 \times 196 = \mathbf{-14.1\ gal/yr}$$

4.1.3 Data Analysis

Estimation of [Σ other] – Since the surface is liquid there is no waste subsidence.

The BBI shows zero retained gas in tank B-203. Buildup and release of gases within the waste has been observed in double-shell tanks (DSTs) as evidenced by a slow increase in the waste level followed by a sudden decrease when the gas is released. Some SSTs may exhibit chronic release of gases at roughly the same rate gases are generated. A buildup of retained gas in the tank over a number of years followed by a steady release over >25 years is not expected based upon past experience. Additionally, monitoring for gases was performed prior to the in-tank video on May 1, 2013. Results recorded on industrial hygiene sample DRI-13-01498 showed 0.0 ppm flammable gas, 0.0 ppm ammonia and 47 ppb volatile organic compounds (VOC). It is assumed there is no retained gas impact on the level decrease even if there is retained gas in the tank.

No large items of equipment are known to have been lanced into the tank in the past 10 years and the TWINS database indicates no samples have been taken from the tank in that time. The water usage data sheets were not reviewed, but making the assumption that a level gauge is flushed with a nominal 10 gal of water every two years results in a nominal 5 gal/yr conscious liquid addition.

The last waste solids were put into the tank in ~1952. The assumption is made that any significant chemical changes that may occur within the waste would have already occurred so the potential for chemical reactions to be causing changes that would affect the level data is very small.

Therefore, the value [Σ other] for B-203 is assumed to be = 0 + 0 + 5 + 0 = 5 gal/yr.

Potential for Intrusion - Per Section 4.1.4, no evidence of intrusion was observed during the in-tank videos taken in tank B-203. Figure 3 and Figure 4 do not show evidence of any intrusion. The annual cycles for the liquid level in the tank are typical for most tanks with a moist or liquid surface.

From Section 3.4:

$$intrusion\ rate = volumetric\ change\ rate - leak\ rate - evaporation\ rate - \Sigma\ other$$

$$intrusion\ rate = -14.1\frac{gal}{yr} - leak\ rate - evaporation\ rate - 5\frac{gal}{yr}$$

$$= -19.1\frac{gal}{yr} - leak\ rate - evaporation\ rate$$

Since both evaporation rate and leak rate are negative values, the sum of the leak rate plus the evaporation rate would have to be <-19.1 gal/yr before an intrusion would be considered. As described below, evaporation is estimated to be -23.1 gal/yr so a small intrusion is theoretically possible if the evaporation rate and volumetric change rate are accurate.

Evaluation of ILL or SL Validity – There is no LOW in the tank, the volumetric change rate is based upon SL data.

The Enraf plummet is sitting on liquid, it can be seen in Figure 5. There is no concern for data impact from debris or a rough surface.

Table 3 lists all tank B-203 ENRAF work packages for the 2006 to 2013 time period. The last two columns list the as-found and as-left data from the work packages. There is negligible change from calibration to calibration, there is no calibration impact change affecting the level decrease rate.

The SL reference was changed from the bottom of the knuckle to the tank centerline bottom in June of 2000 when the Enraf was installed. The level change rate is based upon data after this change.

It is assumed the SL data for tank B-203 are valid.

Table 3 Tank B-203 Enraf Gauge Work Packages Since January 1, 2006

Work Package No.	Title	Date	As Found (in.)	As Left (in.)
CLO-WO-06-002100	241-B, 203 ENRAF INSPECTION	12/13/2006	264.90	264.90
CLO-WO-07-1303	241-B, 203 ENRAF INSPECTION	9/6/2007	264.80	264.81
CLO-WO-08-0719	241-B, 203 ENRAF CAL	8/20/2008	264.69	264.70
TFC-WO-09-1850	241-B, 203 ENRAF CAL	6/2/2009	264.59	264.57
TFC-WO-09-3010	241-B, 203 ENRAF CAL	3/5/2010	264.58	264.57
TFC-WO-11-0456	241-B, 203 ENRAF CAL	9/6/2011	264.56	264.54
TFC-WO-12-2926	241-B, 203 ENRAF CAL	9/15/2012	264.49	264.61

4.1.4   In-Tank Video Results

In-tank videos were obtained in tank B-203 on May 1, 2013 and May 20, 2013. The following discussion is limited to results of the in-tank video information as it relates to evaluation of the tank for level change; i.e., the waste surface, the Enraf plummet, and evidence of intrusion.

The waste surface in tank B-203 is 100% liquid. This is shown in Figure 6, which is a composite of screen images from the May 20, 2013 video.

The Enraf plummet was lowered to the top of the sludge below the liquid, the resulting depth was 7.6 in. If this is an accurate representation of the average liquid depth in the tank, the tank has about 1,500 gal of supernatant liquid.

No drips were noted and no evidence of past intrusion was observed.

4.1.5   Evaporation Estimate

Figure 7 provides the evaporation estimate results for tank B-203. Derivation of the evaporation rate for tank B-203 is described in RPP-RPT-54981, Revision 0, Appendix A. See Appendix A, Section A.5 for calculation estimate details.

The blue line in Figure 7 shows the estimated evaporation rate from tank B-203 as a function of the RH in the tank vapor space. The evaporation rate plot is of limited use without knowing the approximate RH in the tank. No past vapor sample RH data are available for tank B-203 but RPP-RPT-54981, Revision 0, Appendix A, Section A.6 derives a RH value for the tank based upon past vapor sample data for a similar tank (tank B-202) with similar waste and temperature,

less liquid, and greater headspace volume. The estimated average RH value for tank B-203 is indicated by the vertical black line.

Where the vertical black RH line crosses the blue evaporation line in Figure 7 is the best estimate for evaporation from tank B-203, assuming the parameters used in RPP-RPT-54981, Revision 0, Appendix A are valid. Figure 7 indicates the tank B-203 evaporation rate is -23.1 gal/yr.

RPP-RPT-54981, Revision 0, Appendix A describes the variables involved with the evaporation rate estimate and provides a basis for the value selected. The ambient air conditions and tank headspace temperatures are obtained from recorded data. The primary variables in Appendix A that will impact the tank B-203 evaporation rate are the assumed breathing rate and the assumed tank headspace relative humidity.

The breathing rate used for 20 ft. diameter tank B-203, 1.03 cfm, is about half that used for most 75 ft. diameter tanks in RPP-RPT-54981, Revision 0. The tank breathing rates derived in RPP-RPT-54981, Revision 0, Appendix A are based on tracer gas tests performed in the 1996 to 1998 time period. No tracer gas tests were performed in 200-series tanks. The breathing rate derivations provided in RPP-RPT-54981, Revision 0, Appendix A are comprised of a variable rate and a fixed rate. The variable rate is dependent upon the tank headspace volume and the fixed rate is an average of the fixed rates calculated for the tanks in which tracer gas tests were performed. The fixed rate should be proportional to the number of tank connections to the atmosphere and the cross-sectional area of those openings. The 200-series tanks have a similar number of penetrations and openings as the 75 ft. diameter tanks in B, C, T, U, and BX farms, but for conservatism the fixed rate portion of the breathing rate for 200-series tanks was assumed only half of that for a 75 ft. diameter tank. This results in the B-203 breathing rate to be a little less than half of the breathing rates for 75 ft. diameter tanks because the variable portion of the breathing rate for 200-series tanks is assumed very low due to the small headspace volume compared to that in 75 ft. diameter tanks.

The complete basis for the breathing rate assumed for tank B-203 is provided in RPP-RPT-54981, Revision 0, Appendix A and is the best estimate available when considering the information, but the actual rate could be higher or lower than assumed. Changing the breathing rate would result in a proportional change in the evaporation rate.

The assumed tank B-203 headspace RH of 92% is based upon the 1996 vapor space sample in tank B-202 showing water vapor present at 91.7%. The tank B-202 sample was obtained when the headspace temperature was 61°F. When sampled, tank B-202 had a waste surface level of 146.25 in. Since tank B-203 has a smaller headspace volume than tank B-202 and a 100% liquid surface it must have a similar or greater RH than tank B-202 in 1996. Thus it is reasonable to assume the RH should be about 92%.

In conclusion, an evaporation rate of ~-23 gal/yr for tank B-203 appears reasonable.

4.1.6   Tank Heat Generation Rate Impact

RPP-54981, Revision 0, Appendix B describes the process used to estimate a heat generation rate for the waste in a tank. Table 4 in this document lists the nuclides contributing >0.01 percent to the tank B-203 heat generation rate, which is about 7.5 BTU/hr. This is based upon a radionuclide decay date of January 1, 2008, so the heat generation rate as of July 1, 2013 is slightly less. The heat generation rate is negligible, the energy for evaporation from the tank has to come from the latent heat of the incoming air, surrounding waste, and soil.

Table 4 Radionuclides Contributing Greater Than 0.01% to the Tank B-203 Waste Heat Generation Rate

Radionuclide	Ci[1]	Heat Generation Rate (watts/Ci)[2]	Heat Generation Rate (watts)
90Sr	1.41E+01	6.70E-03	9.44E-02
90Y	1.41E+01	0.00E+00 (with parent)	0.00E+00
137Cs	1.35E+00	4.82E-03	6.50E-03
137mBa	1.35E+00	0.00E+00 (with parent)	0.00E+00
151Sm	1.33E+00	1.17E-04	1.56 E-04
238Pu	4.38E-01	3.32E-02	1.45E-02
239Pu	5.23E+01	3.11E-02	1.63E+00
240Pu	6.59E+00	3.12E-02	2.05E-01
241Am	7.75E+00	3.34E-02	2.59E-01
241Pu	1.04E+01	3.18E-05	3.30E-04
Sum			2.2 (7.5 BTU/hr)

[1] From TWINS download March 19, 2013, radionuclide decay date January 1, 2008
[2] From HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, Rev 14 (reissue), August 11, 2008

4.1.7   Tank B-203 Leak Potential

Based upon Figure 7 the tank B-203 estimated evaporation rate can account for the observed liquid loss rate.

Using the equation from Section 3.4:

$$leak\ rate = volumetric\ change\ rate - intrusion\ rate - evaporation\ rate - \Sigma\ other$$

$$leak\ rate = -14.1\frac{gal}{yr} - intrusion\ rate - (-23.1\frac{gal}{yr}) - \left(5\ \frac{gal}{yr}\right)$$

$$= 4\frac{gal}{yr} - intrusion\ rate$$

If the evaporation rate for tank B-203 is -23.1 gal/yr, the intrusion rate would have to exceed 4 gal/yr, for a leak to exist. Based upon Figure 7 the tank B-203 liquid loss rate can be explained by evaporation.

4.1.8   Tank B-203 Conclusion

There is no basis to assume a leak from tank B-203.

Figure 1 Tank B-203 Full Depth Raw Data Plot

BBI 9-25-12

0 kgal retained gas
0.5 kgal supernate
0 kgal saltcake + liquids
49.7 kgal sludge + liquids
Top solids layer mostly sludge
$1.41 \text{ E+01 Ci } ^{90}\text{Sr}$
$4.16 \text{ E-06 Ci } ^{99}\text{Tc}$
$1.35 \text{ E+00 Ci } ^{137}\text{Cs}$
$5.23 \text{ E+01 Ci } ^{239}\text{Pu}$

Level (Inches)

Date

MT and Enraf
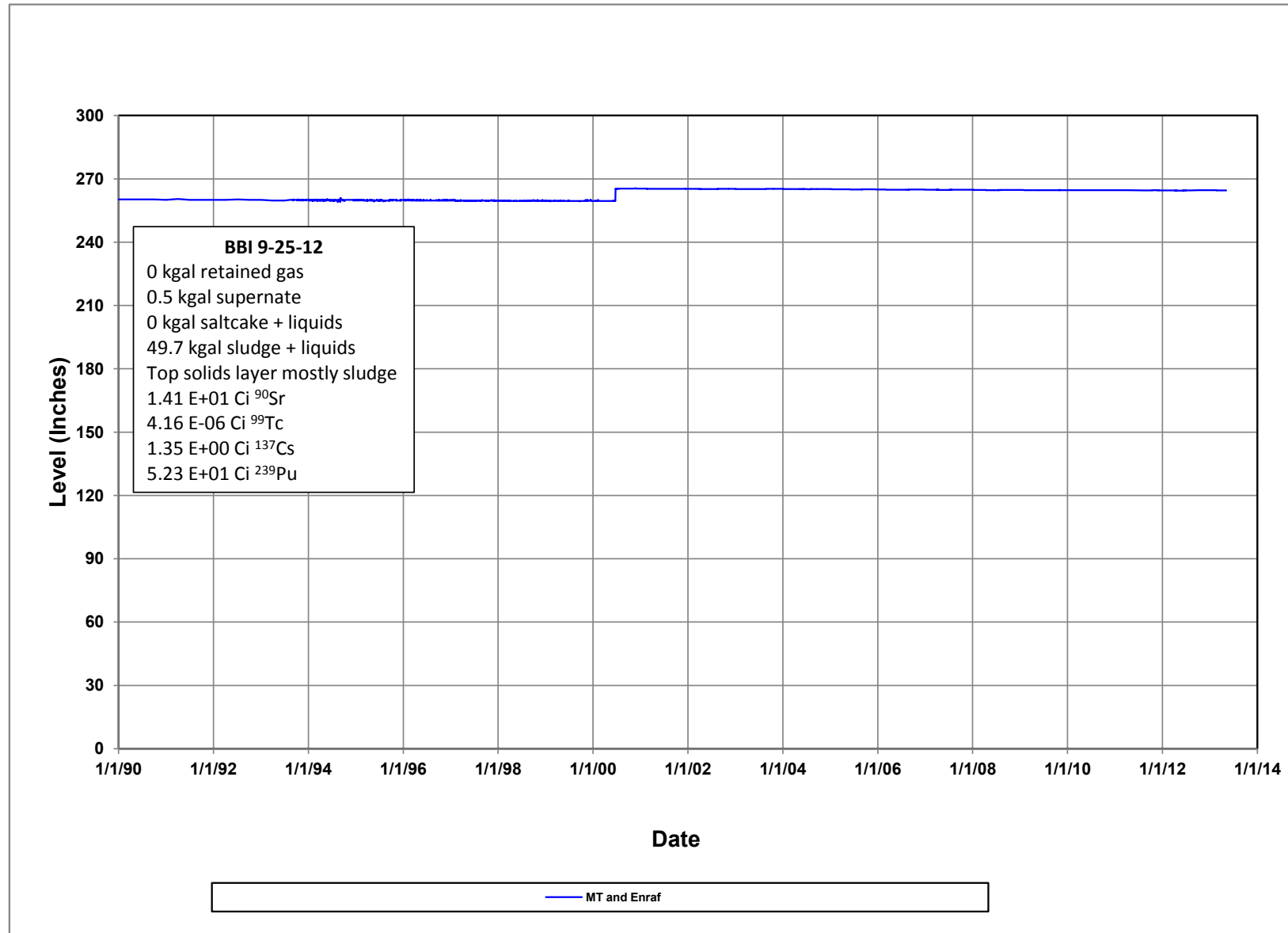
Figure 2 B-203 Expanded SL Data Plot Used for RPP-PLAN-55113, Rev 1
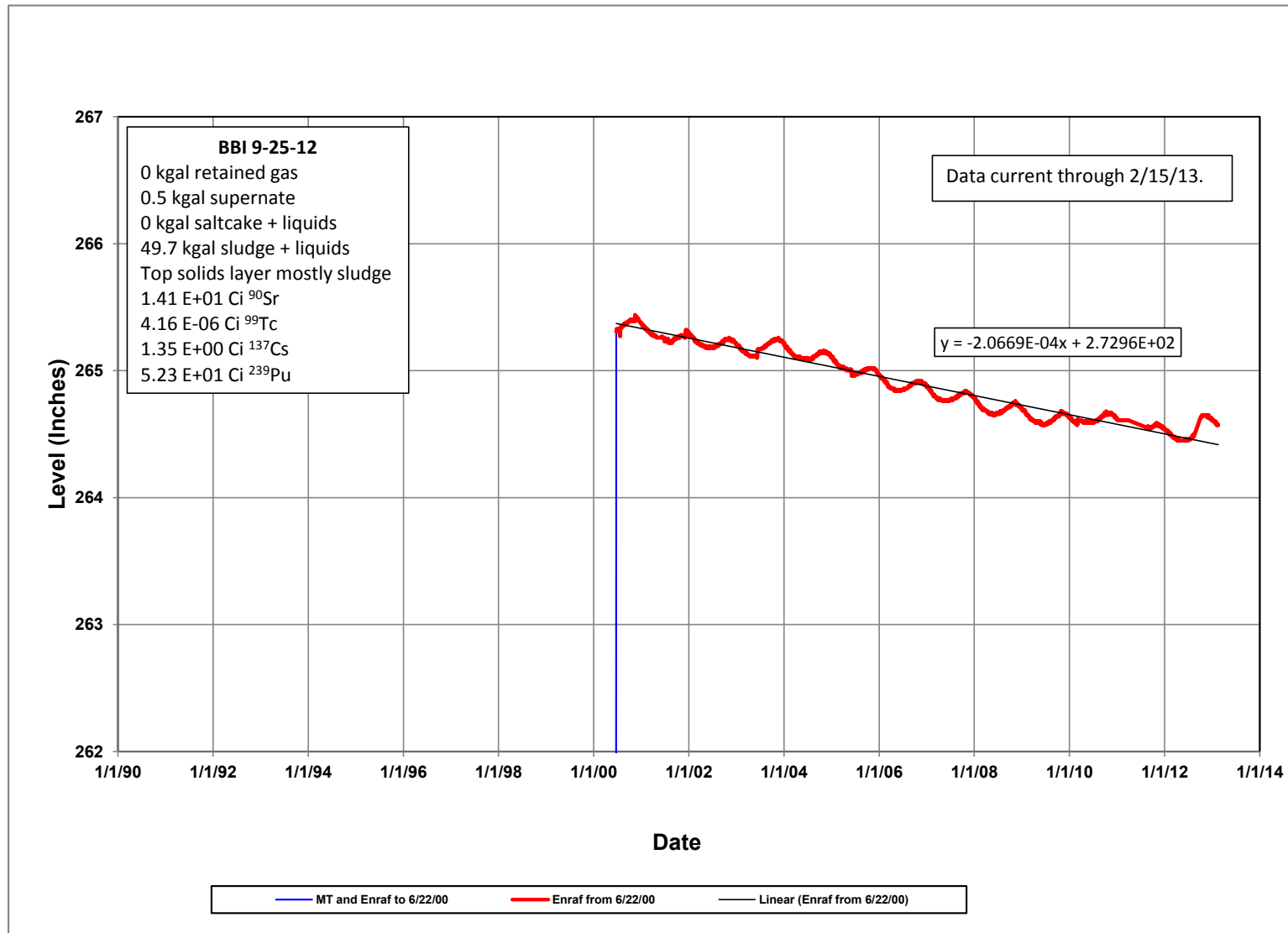
Figure 3 Tank B-203 Expanded SL Data Plot Used for RPP-RPT-55265

BBI 9-25-12
0 kgal retained gas
0.5 kgal supernate
0 kgal saltcake + liquids
49.7 kgal sludge + liquids
Top solids layer mostly sludge
1.41 E+01 Ci ^{90}Sr
4.16 E-06 Ci ^{99}Tc
1.35 E+00 Ci ^{137}Cs
5.23 E+01 Ci ^{239}Pu

Data current through 9/3/13.

$y = -1.9826E-04x + 2.7264E+02$

MT and Enraf to 6/22/00   Enraf from 6/22/00   Linear (Enraf from 6/22/00)
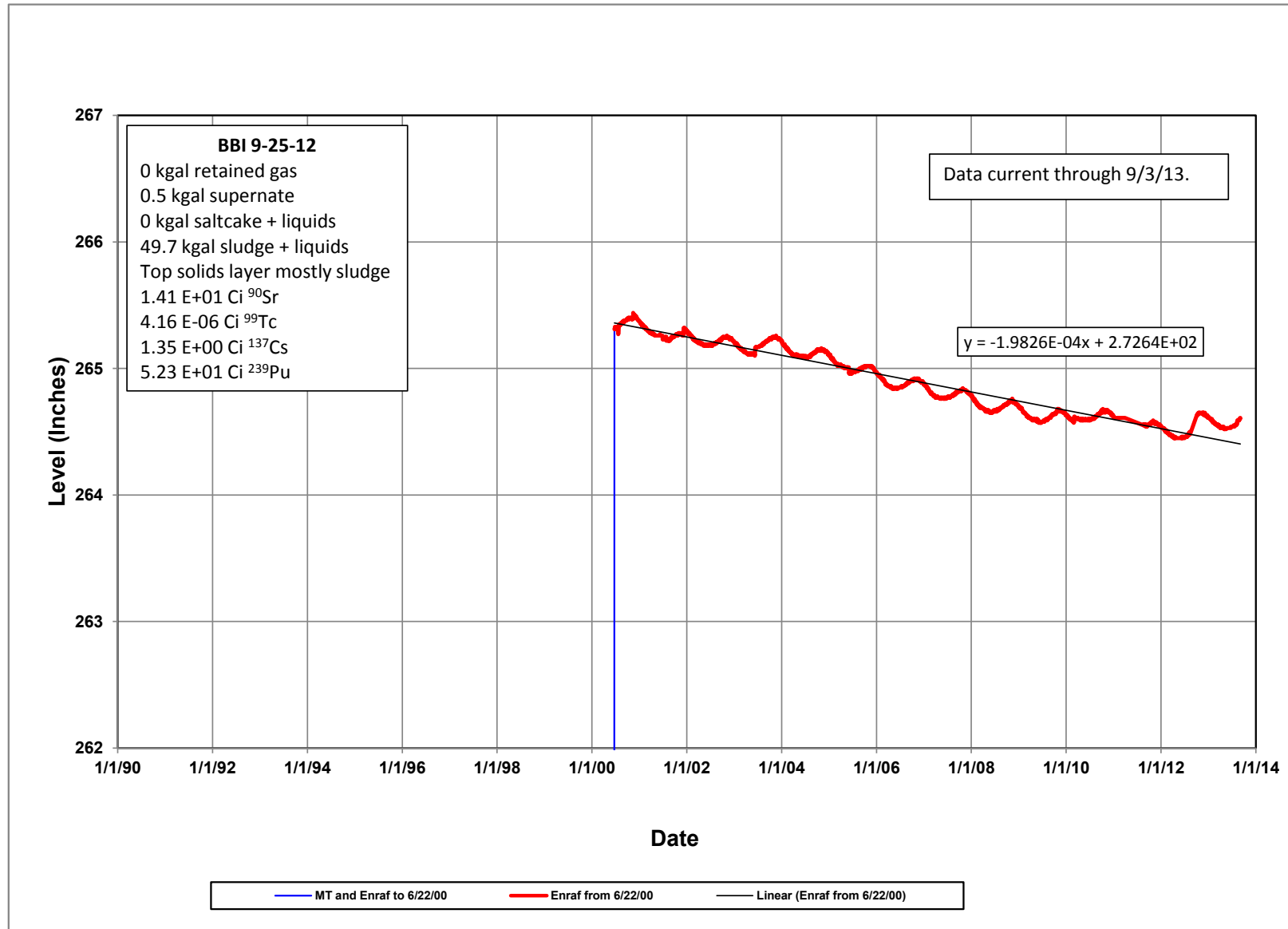
Figure 4 Tank B-203 Expanded and Adjusted SL Data Plot from 1980

Data current through 9/3/13. Manual tape data have 6 inches added to every data point to account for reference level change on 6/22/2000.

BBI 9-25-12
0 kgal retained gas
0.5 kgal supernate
0 kgal saltcake + liquids
49.7 kgal sludge + liquids
Top solids layer mostly sludge
1.41 E+01 Ci ^{90}Sr
4.16 E-06 Ci ^{99}Tc
1.35 E+00 Ci ^{137}Cs
5.23 E+01 Ci ^{239}Pu

Level (Inches)

Date

All
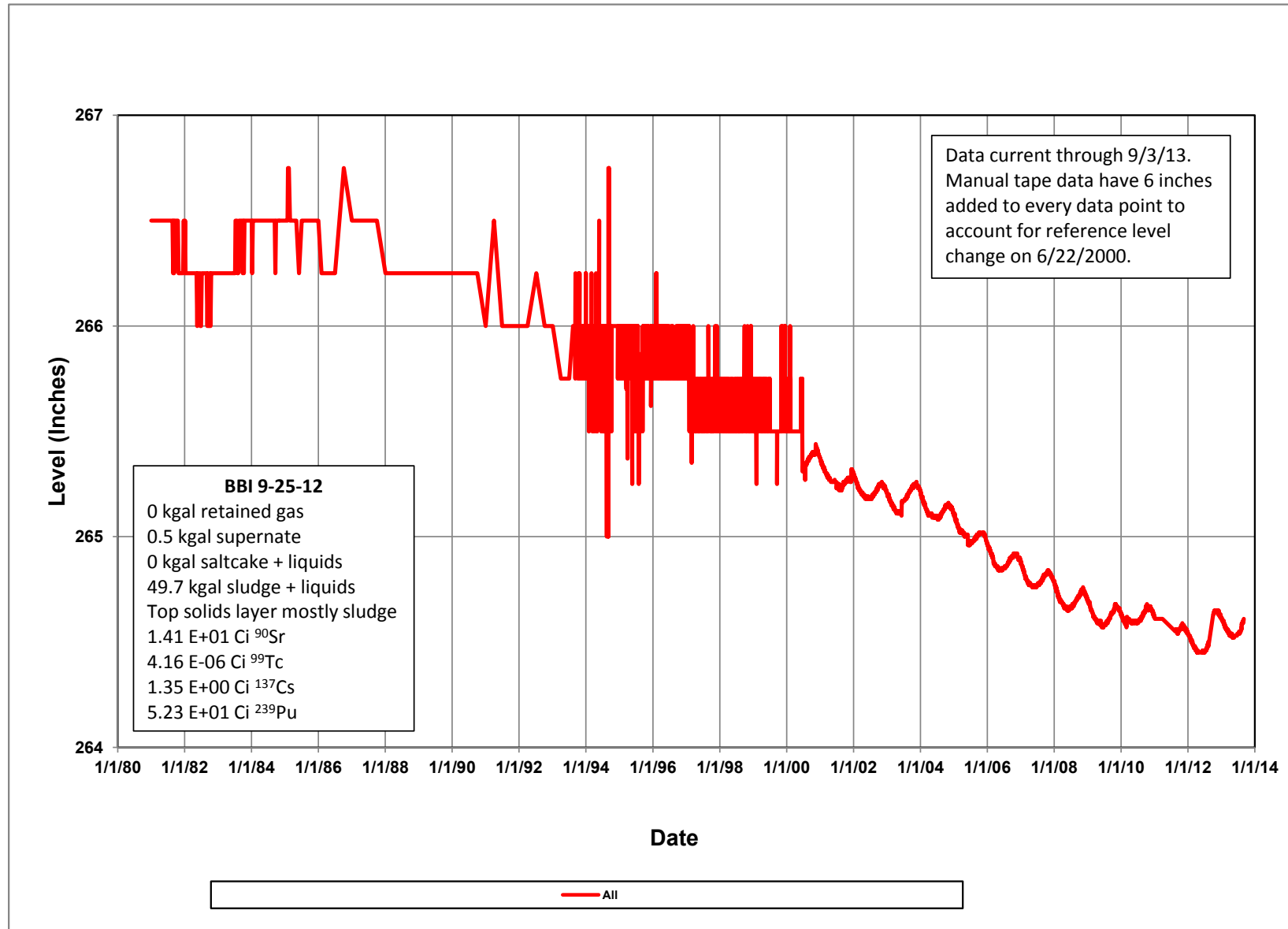
Figure 5 Tank B-203 Enraf Plummet

Enraf Plummet on liquid surface.

Figure 6 Screen Image Composite of Tank B-203 Waste Surface from May 20, 2013 In-Tank Video
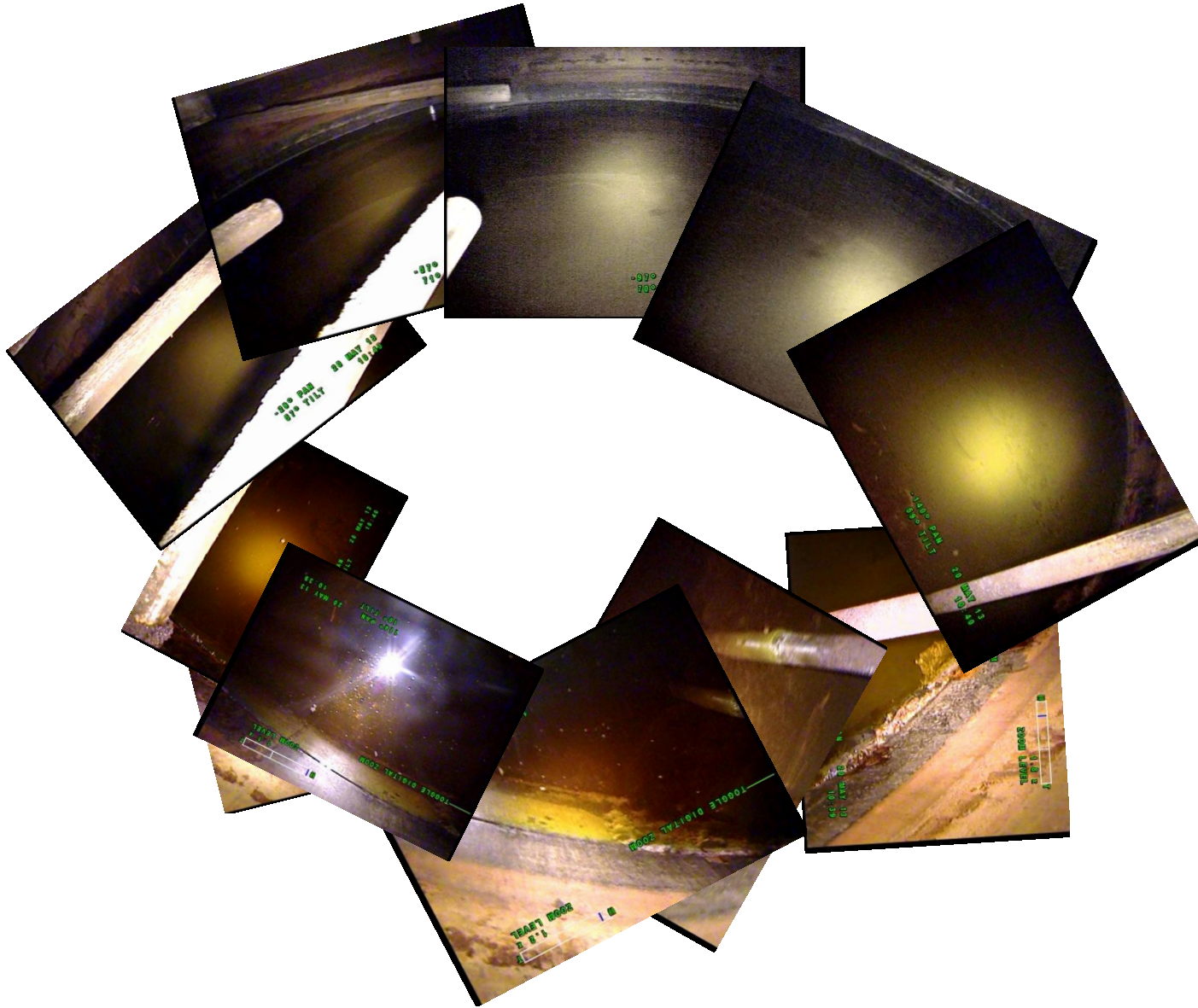
Figure 7 Tank B-203 Estimated Evaporation Loss Rate and Observed Liquid Loss Rate

No LOW in tank, loss rate based upon Enraf change of -0.072 in./yr.
8 BTU/hr heat generation rate (January 1, 2008 decay date).
Annual headspace temperature range 56-68°F.

Estimated evaporation rate -23.1 gal/yr at assumed breathing rate and headspace relative humidity. Evaporation rate at the headspace RH exceeds liquid loss rate. There is no evidence to indicate the tank is leaking.

Estimated liquid loss rate, 100% of surface is liquid.

Relative Humidity in Tank Headspace

-1 × Gallons per year

Estimated Evaporation Rate   Estimated Liquid Loss Rate   Estimated Headspace Relative Humidity

4.2 Tank B-204

4.2.1 Tank Summary

Tank B-204 was put into service in 1948 when it received 224 waste (plutonium purification cycle waste) from B-Plant. It was filled by 1952, but is reported to have received occasional flush solution transfers up to 1963. Most of the supernate was transferred out to an SST in 1974. It was declared an assumed leaker in 1984 and interim stabilization was documented as complete in 1984 (RPP-RPT-42958, *2009 Auto TCR for Tank 241-B-204,* Revision 0, WHC-MR-0132, 1990, *A History of The Hanford 200 Area Tank Farms*, Revision 0, HNF-EP-0182, Rev 301, HNF-SD-WM-TI-178, 1007, *Single-Shell Tank Interim Stabilization Record,* Rev 9a). Per a TWINS query on September 25, 2012 the tank contains 48.6 kgal sludge and 0.8 kgal supernatant liquid.

Figure 8 shows the raw SL data for tank B-204 from January 1, 1990. Figure 9 is a plot of the data used for calculation of the -0.070 in./yr trendline slope for the Enraf portion of the data used for RPP-RPT-55113, Rev 1, with an expanded y-axis so the SL data changes can be seen. The SL shows a fairly constant decrease since before 1990. The SL data for Figure 8 and Figure 9 are from a TWINS tank surface level data download on February 15, 2013. Figure 10 is an updated plot showing the latest data included for this document. The slope of the decrease line is essentially the same at -0.068 in./yr as of September 3, 2013. The SL data for Figure 10 are from a TWINS tank surface level data download on September 4, 2013.

Figure 11 is a plot from 1980 with the manual tape data (adjusted by having 6 inches added to it to account for the reference level change on June 22, 2000) and the ENRAF data combined. This plot indicates the decrease rate in tank B-203 has been fairly consistent for close to 25 years.

4.2.2 Liquid Change Rate Estimation

The waste porosity is not a factor since the tank has a 100% liquid surface per the in-tank video(s).

The estimated tank B-204 liquid change rate is:

$$Tank\ B - 204\ estimated\ liquid\ change\ rate = -0.068 \times 196 = -\mathbf{13.4}\ \boldsymbol{gal/yr}$$

4.2.3 Data Analysis

Estimation of [Σ other] – Since the surface is liquid there is no waste subsidence.

The BBI shows zero retained gas in tank B-204. Buildup and release of gases within the waste has been observed in double-shell tanks (DSTs) as evidenced by a slow increase in the waste level followed by a sudden decrease when the gas is released. Some SSTs may exhibit chronic release of gases at roughly the same rate gases are generated. A buildup of retained gas in the tank over a number of years followed by a steady release over >25 years is not expected based upon past experience. Additionally, monitoring for gases was performed prior to the in-tank video on May 23, 2013. Results recorded on industrial hygiene sample DRI-13-01766 showed 0.0 ppm flammable gas, 0.0 ppm ammonia, and 0.0 ppb VOCs. It is assumed there is no retained gas impact on the level decrease even if there is retained gas in the tank.

No large items of equipment are known to have been lanced into the tank in the past 10 years and the TWINS database indicates no samples have been taken from the tank in that time. The water

usage data sheets were not reviewed, but making the assumption that a level gauge is flushed with a nominal 10 gal of water every two years results in a nominal 5 gal/yr conscious liquid addition.

The last waste solids were put into the tank in ~1952. The assumption is made that any significant chemical changes that may occur within the waste would have already occurred so the potential for chemical reactions to be causing changes that would affect the level data is very small.

Therefore, the value [Σ other] for B-204 is assumed to be = 0 + 0 + 5 + 0 = 5 gal/yr.

Potential for Intrusion - Per Section 4.2.5, no evidence of intrusion was observed during the in-tank videos taken in tank B-204. Figure 10 and Figure 11 do not show evidence of any intrusion. The annual cycles for the liquid level in the tank are typical for most tanks with a moist or liquid surface.

From Section 3.4:

$$intrusion\ rate = volumetric\ change\ rate - leak\ rate - evaporation\ rate - \Sigma\ other$$

$$intrusion\ rate = -13.4\frac{gal}{yr} - leak\ rate - evaporation\ rate - 5\frac{gal}{yr}$$

$$= -18.4\frac{gal}{yr} - leak\ rate - evaporation\ rate$$

Since both evaporation rate and leak rate are negative values, the sum of the leak rate plus the evaporation rate would have to be <-18.4 gal/yr before an intrusion would be considered. As described below, evaporation is estimated to be -23.6 gal/yr so a small intrusion is possible if the evaporation rate and volumetric change rate are accurate.

Evaluation of ILL or SL Validity – There is no LOW in the tank, the volumetric change rate is based upon SL data.

The Enraf plummet is sitting on liquid, it can be seen in Figure 12. There is no concern for data impact from debris or a rough surface.

Table 5 lists all tank B-204 ENRAF work packages for the 2006 to 2013 time period. The last two columns list the as-found and as-left data from the work packages. There is negligible change from calibration to calibration, there is no calibration impact change affecting the level decrease rate.

Table 5 Tank B-204 Enraf Gauge Work Packages Since January 1, 2006

Work Package No.	Title	Date	As Found (in.)	As Left (in.)
CLO-WO-06-002105	241-B, 204 ENRAF INSPECTION	12/13/2006	261.22	261.23
CLO-WO-07-1302	241-B, 204 ENRAF INSPECTION	9/6/2007	261.12	261.13
CLO-WO-08-0718	241-B, 204 ENRAF CAL	8/20/2008	261.01	261.02
TFC-WO-09-1852	241-B, 204 ENRAF CAL	6/2/2009	260.84	260.83
TFC-WO-11-0457	241-B, 204 ENRAF CAL	12/1/2011	260.77	260.86
TFC-WO-11-4930	241-B REPAIR B-204 ENRAF	12/1/2011	NA	NA
TFC-WO-12-2937	241-B, 204 ENRAF CAL	9/5/2012	260.84	260.85

The SL reference was changed from the bottom of the knuckle to the tank centerline bottom in June of 2000 when the Enraf was installed. The level change rate is based upon data after this change.

It is assumed the SL data for tank B-204 are valid.

4.2.4   In-Tank Video Results

An in-tank video was obtained in tank B-204 on May 23, 2013. The following discussion is limited to results of the in-tank video information as it relates to evaluation of the tank for level change; i.e., the waste surface, the Enraf plummet, and evidence of intrusion.

The waste surface in tank B-204 is 100% liquid. This is shown in Figure 13, which is a composite of screen images from the May 23, 2013 video.

The Enraf plummet was lowered to the top of the sludge below the liquid, the resulting depth was 8.2 in. If this is an accurate representation of the average liquid depth in the tank, the tank has about 1,600 gal of supernatant liquid.

No drips were noted and no evidence of past intrusion was observed. Evidence of possible minor intrusions was observed on an area of the tank wall between the top of the waste and the tank ceiling. These are shown in Figure 14 but not believed to indicate any significant liquid addition to the tank.

4.2.5   Evaporation Estimate

Figure 15 provides the evaporation estimate results for tank B-204. Derivation of the evaporation rate from tank B-204 is described in RPP-RPT-54981, Revision 0, Appendix A. See Appendix A, Section A.5 for calculation estimate details.

The blue line in Figure 15 shows the estimated evaporation rate from tank B-204 as a function of the RH in the tank vapor space. The evaporation rate plot is of limited use without knowing the approximate RH in the tank. No past vapor sample RH data are available for tank B-204 but RPP-RPT-54981, Revision 0, Appendix A, Section A.6 derives a RH value for the tank based upon past vapor sample data for a similar tank (tank B-202) with similar waste and temperature, less liquid, and greater headspace volume. The estimated average RH value for tank B-204 is indicated by the vertical black line.

Where the vertical black RH line crosses the blue evaporation line in Figure 15 is the best estimate for evaporation from tank B-204, assuming the parameters used in RPP-RPT-54981, Revision 0, Appendix A are valid. Figure 15 indicates the tank B-204 evaporation rate is -23.6 gal/yr.

RPP-RPT-54981, Revision 0, Appendix A describes the variables involved with the evaporation rate estimate and provides a basis for the value selected. The ambient air conditions and tank headspace temperatures are obtained from recorded data. The primary variables in Appendix A that will impact the tank B-204 evaporation rate are the assumed breathing rate and the assumed tank headspace relative humidity.

The breathing rate used for 20 ft. diameter tank B-204, 1.03 cfm, is about half that used for most 75 ft. diameter tanks in RPP-RPT-54981, Revision 0. The tank breathing rates derived in RPP-RPT-54981, Revision 0, Appendix A are based on tracer gas tests performed in the 1996 to 1998 time period. No tracer gas tests were performed in 200-series tanks. The breathing rate

derivations provided in RPP-RPT-54981, Revision 0, Appendix A are comprised of a variable rate and a fixed rate. The variable rate is dependent upon the tank headspace volume and the fixed rate is an average of the fixed rates calculated for the tanks in which tracer gas tests were performed. The fixed rate should be proportional to the number of tank connections to the atmosphere and the cross-sectional area of those openings. The 200-series tanks have a similar number of penetrations and openings as the 75 ft. diameter tanks in B, C, T, U, and BX farms, but for conservatism the fixed rate portion of the breathing rate for 200-series tanks was assumed only half of that for a 75 ft. diameter tank. This results in the B-204 breathing rate to be a little less than half of the breathing rates for 75 ft. diameter tanks because the variable portion of the breathing rate for 200-series tanks is assumed very low due to the small headspace volume compared to that in 75 ft. diameter tanks.

The complete basis for the breathing rate assumed for tank B-204 is provided in RPP-RPT-54981, Revision 0, Appendix A and is the best estimate available when considering the information, but the actual rate could be higher or lower than assumed. Changing the breathing rate would result in a proportional change in the evaporation rate.

The assumed tank B-204 headspace RH of 92% is based upon the 1996 vapor space sample in tank B-202 showing water vapor present at 91.7%. The tank B-202 sample was obtained when the headspace temperature was 61°F. When sampled, tank B-202 had a waste surface level of 146.25 in. Since tank B-204 has a smaller headspace volume than tank B-202 and a 100% liquid surface it must have a similar or greater RH than tank B-202 in 1996. Thus it is reasonable to assume the RH should be about 92%.

In conclusion, an evaporation rate of -23.6 gal/yr for tank B-204 appears reasonable.

4.2.6   Tank Heat Generation Rate Impact

RPP-54981, Revision 0, Appendix B describes the process used to estimate a heat generation rate for the waste in a tank. Table 6 lists the nuclides contributing >0.01 percent to the tank B-204 heat generation rate, which is about 6.3 BTU/hr. This is based upon a radionuclide decay date of January 1, 2008, so the heat generation rate as of July 1, 2013 is slightly less. The heat generation rate is negligible, the energy for evaporation from the tank has to come from the latent heat of the incoming air, surrounding waste, and soil.

Table 6 Radionuclides Contributing Greater Than 0.01% to the Tank B-204 Waste Heat Generation Rate

Radionuclide	Ci[1]	Heat Generation Rate (watts/Ci)[2]	Heat Generation Rate (watts)
90Sr	1.41E+01	6.70E-03	3.48E-03
90Y	1.41E+01	0.00E+00 (with parent)	0.00E+00
137Cs	1.35E+00	4.82E-03	2.52E-02
137mBa	1.35E+00	0.00E+00 (with parent)	0.00E+00
238Pu	4.38E-01	3.32E-02	1.21E-02
239Pu	5.23E+01	3.11E-02	1.36E+00
240Pu	6.59E+00	3.12E-02	1.71E-01
241Am	7.75E+00	3.34E-02	2.81E-01
Sum			1.8 (6.3 BTU/hr)

[1] From TWINS download March 19, 2013, radionuclide decay date January 1, 2008.
[2] From HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, Rev 14 (reissue), August 11, 2008.

4.2.7 Tank B-204 Leak Potential

Based upon Figure 15 the tank B-204 estimated evaporation rate can account for the observed liquid loss rate.

Using the equation from Section 3.4:

$$leak\ rate = volumetric\ change\ rate - intrusion\ rate - evaporation\ rate - \Sigma\ other$$

$$leak\ rate = -13.4\frac{gal}{yr} - intrusion\ rate - (-23.6\frac{gal}{yr}) - \left(5\frac{gal}{yr}\right)$$

$$= 5.2\frac{gal}{yr} - intrusion\ rate$$

If the evaporation rate for tank B-204 is -23.6 gal/yr, the intrusion rate would have to exceed 5.2 gal/yr, for a leak to exist. Based upon Figure 15 the tank B-204 liquid loss rate can be explained by evaporation.

4.2.8 Tank B-204 Conclusion

There is no basis to assume a leak from tank B-204.

Figure 8 Tank B-204 Full Depth Raw Data Plot

BBI 9-25-12
0 kgal retained gas
0.8 kgal supernate
0 kgal saltcake + liquids
48.6 kgal sludge + liquids
Top solids layer mostly sludge
5.20 E-01 Ci ^{90}Sr
3.79 E-06 Ci ^{99}Tc
5.23 E+00 Ci ^{137}Cs
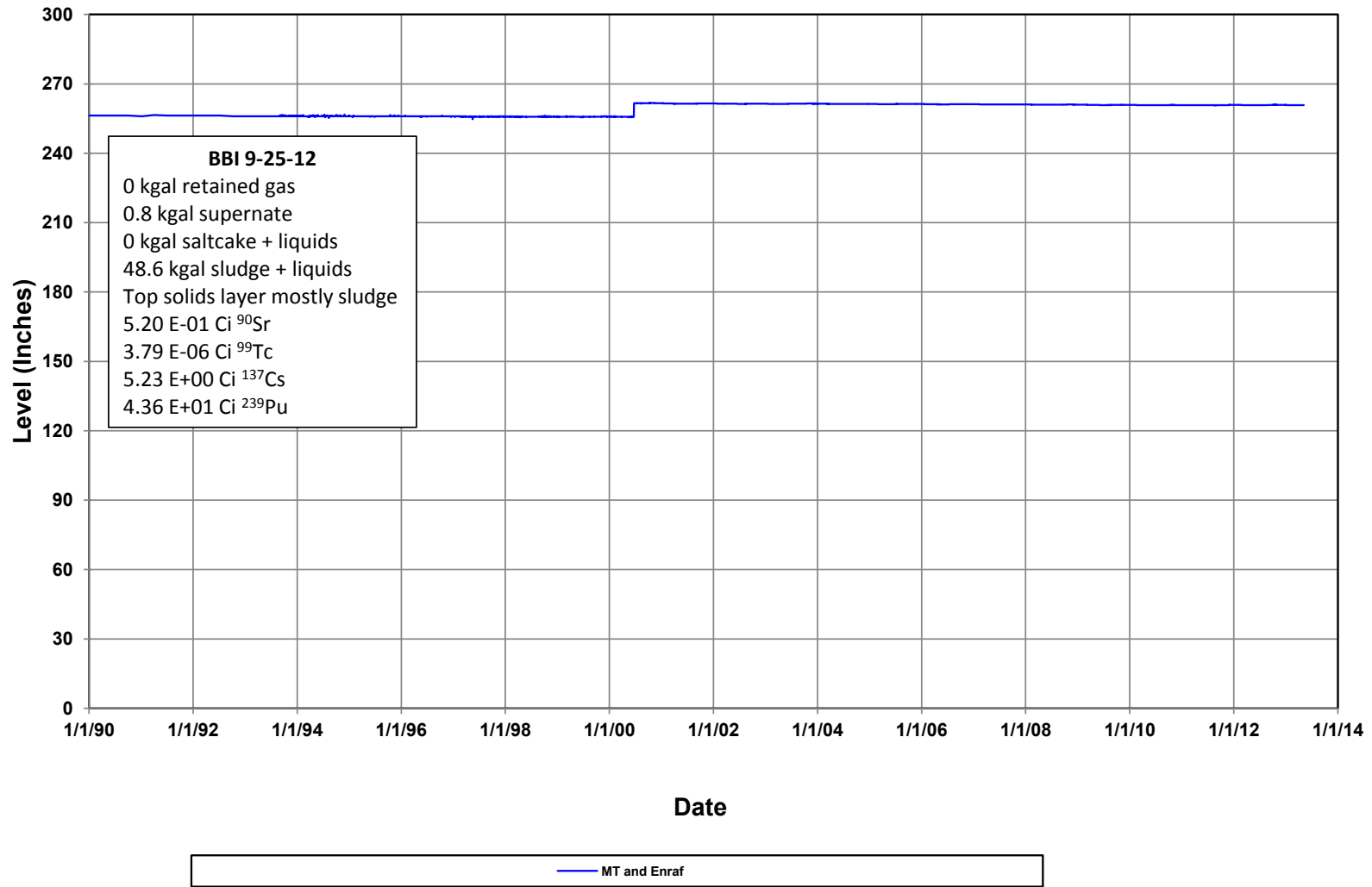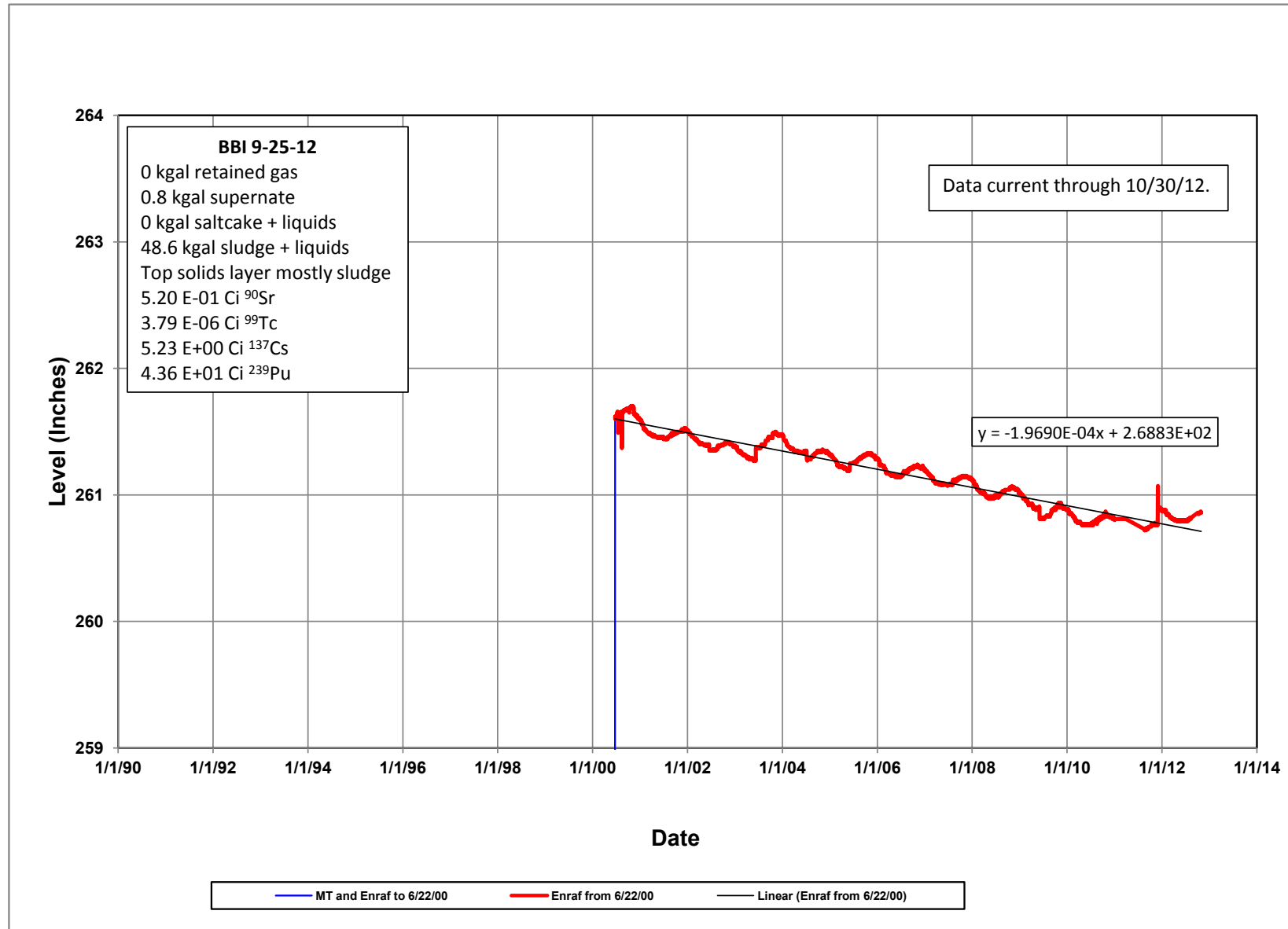4.36 E+01 Ci ^{239}Pu

MT and Enraf

Figure 9 B-204 Expanded SL Data Plot Used for RPP-PLAN-55113, Rev 1

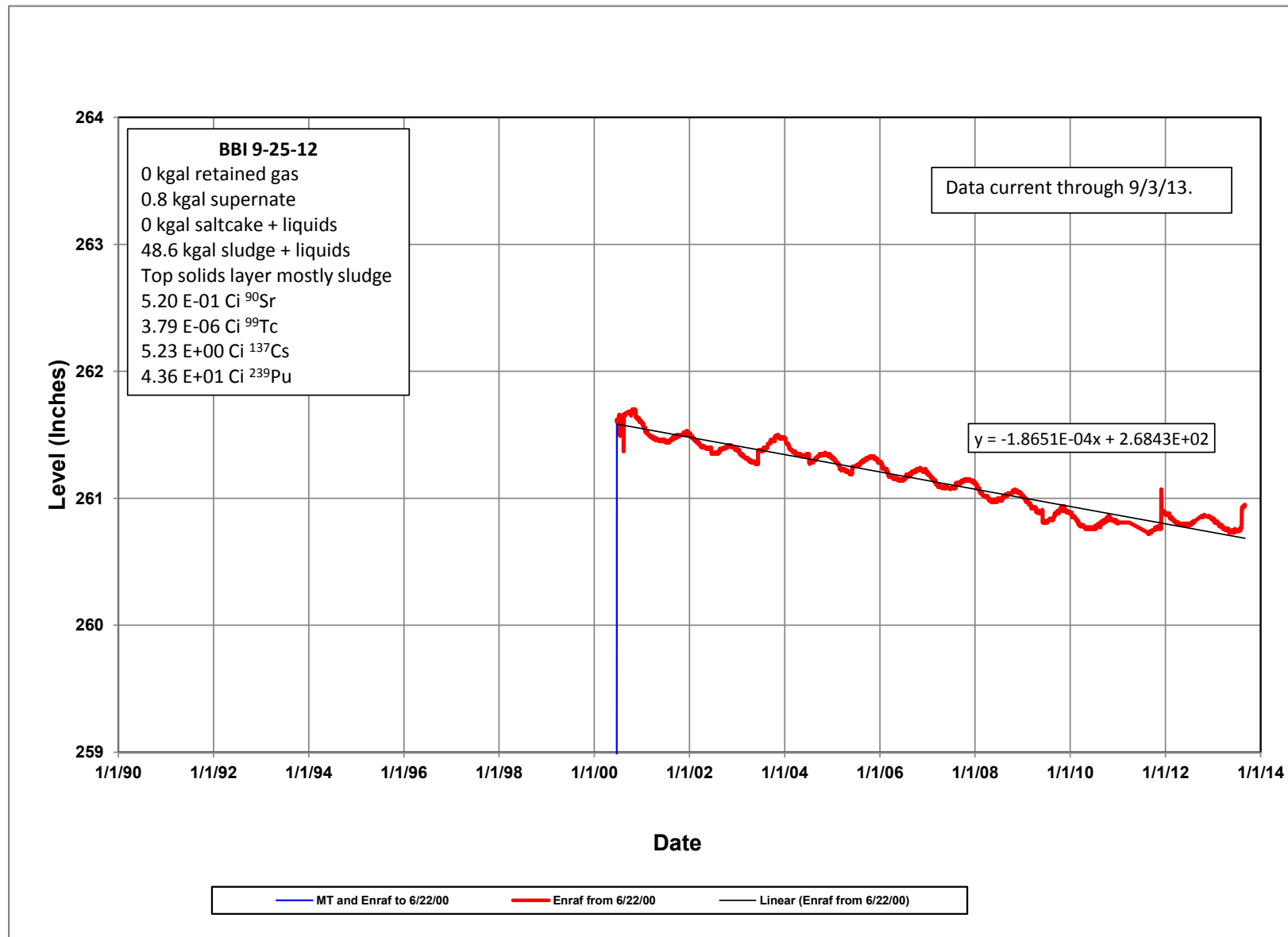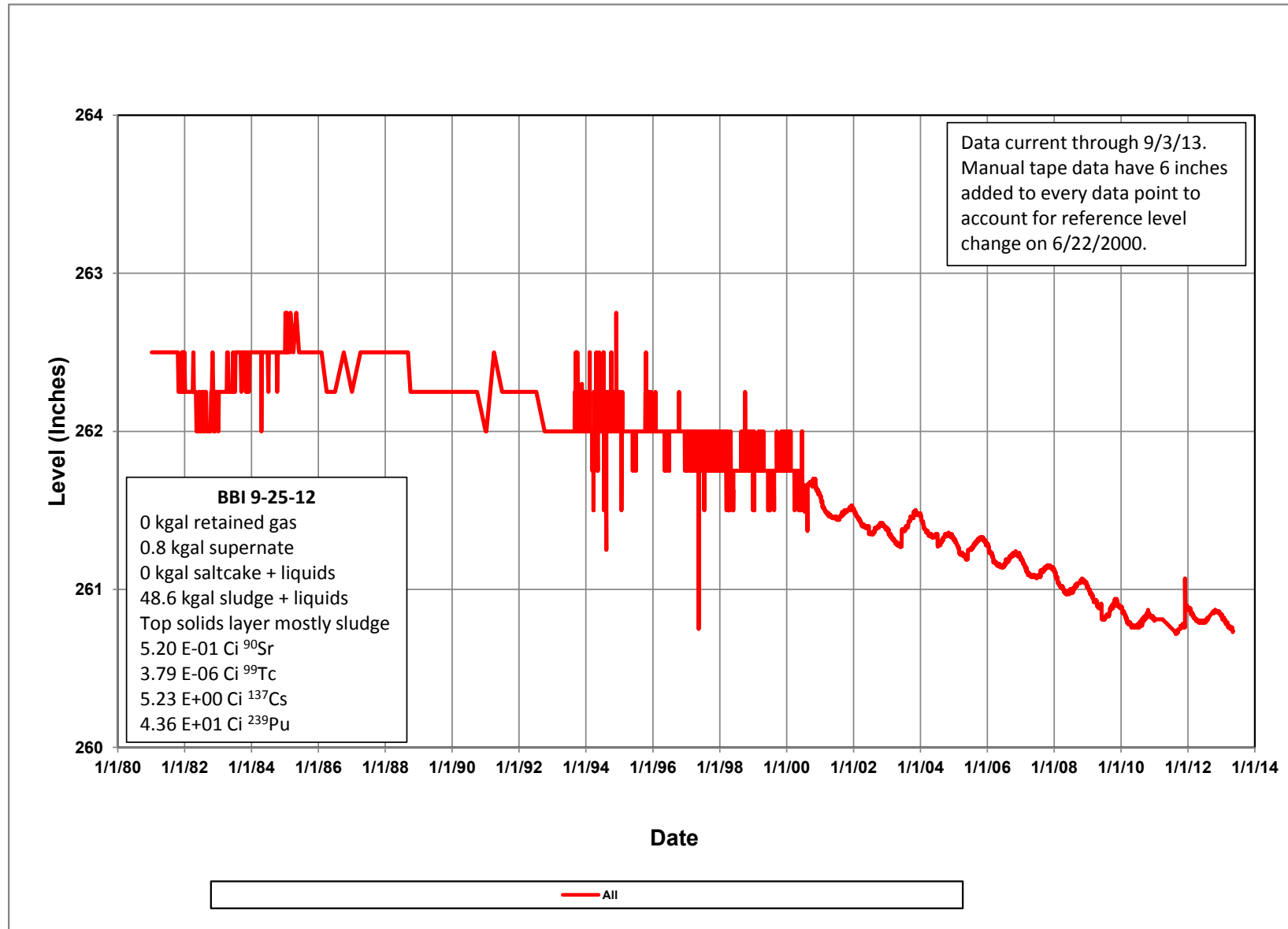**Figure 10 Tank B-204 Expanded SL Data Plot Used for RPP-RPT-55265**

Figure 11 Tank B-204 Expanded and Adjusted SL Data Plot from 1980

Data current through 9/3/13.
Manual tape data have 6 inches
added to every data point to
account for reference level
change on 6/22/2000.

BBI 9-25-12
0 kgal retained gas
0.8 kgal supernate
0 kgal saltcake + liquids
48.6 kgal sludge + liquids
Top solids layer mostly sludge
5.20 E-01 Ci ^{90}Sr
3.79 E-06 Ci ^{99}Tc
5.23 E+00 Ci ^{137}Cs
4.36 E+01 Ci ^{239}Pu

Level (Inches)

Date

All

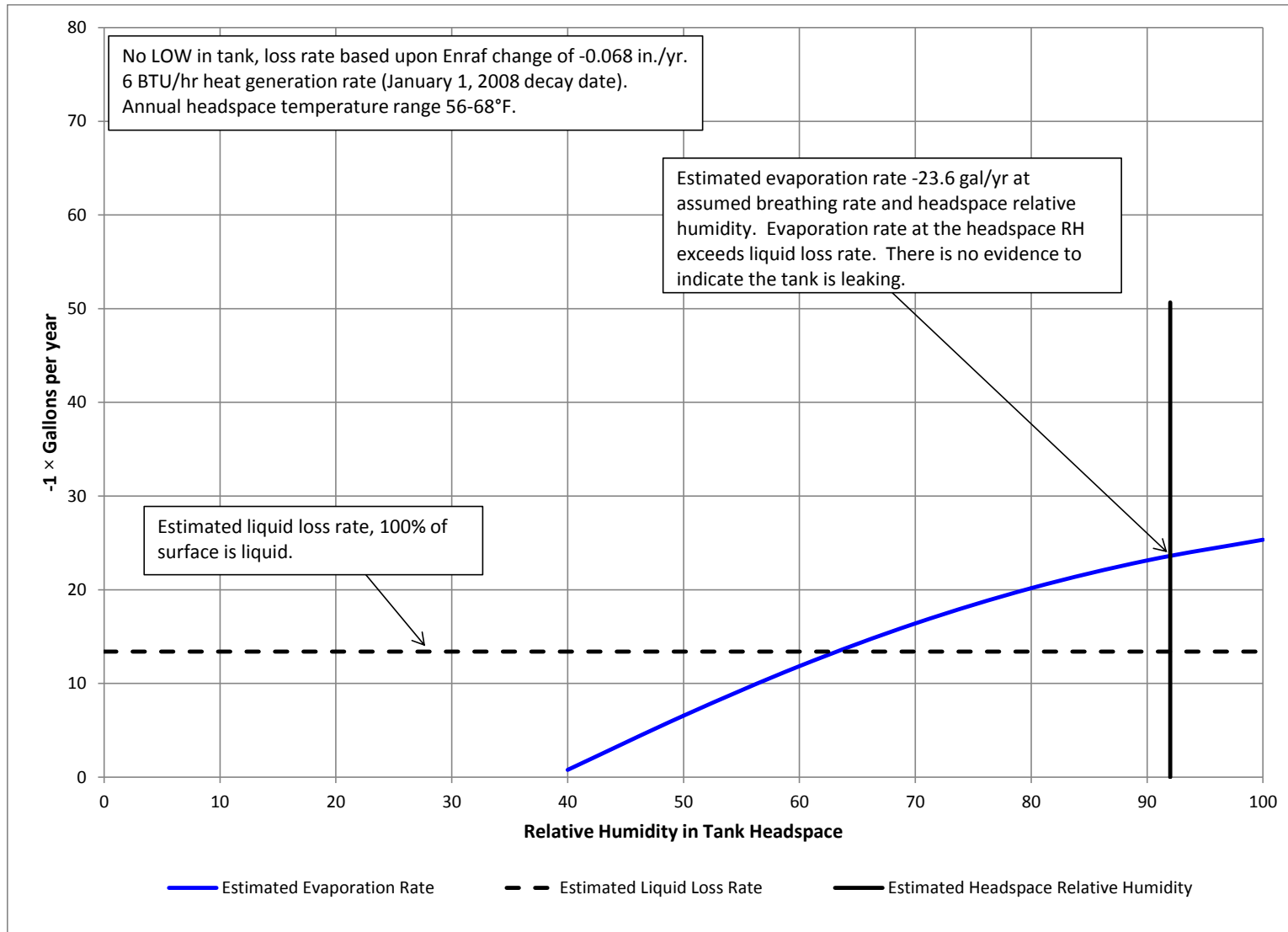**Figure 12 Tank B-204 Enraf Plummet**

Figure 13 Screen Image Composite of Tank B-204 Waste Surface from May 23, 2013 In-Tank Video

Figure 14 Possible Minor Intrusion Evidence on Tank B-204 Wall

Figure 15 B-204 Estimated Evaporation Loss Rate and Observed Liquid Loss Rate

5.0   Discussion of Results

The evaluations for tanks B-203 and B-204 are dependent upon the validity of three separate estimates: evaporation rate, volumetric change rate, and tank headspace relative humidity. The possible variation in these is addressed in the following subsections.

5.1   Evaporation Rate Variation

The tank evaporation rate depends upon the following variables:

- Ambient temperature, pressure, and relative humidity
- Tank headspace air temperature
- Tank headspace relative humidity
- Tank breathing rate
- How a tank breathing rate differs from a once-through active ventilation process with its effect on water vapor condensing out of headspace air before the air reaches the atmosphere.

Ambient conditions are assumed the same as measured at the Hanford Weather Station (HWS). While local conditions at each tank can vary slightly from at the HWS, and the HWS data used is hourly not continuous, any errors in using the HWS are assumed to be minor and should cancel each other out over three years' worth of data.

The tank headspace air temperature is based upon a regression line formula for each tank, which is in turn dependent upon the accuracy of the tank thermocouple used and the degree of variation of the data over the years used for the regression line. The tank thermocouples themselves cannot be calibrated since they are located inside pipes inserted into the waste, but it is assumed that the tank thermocouple data is reasonably accurate as the data points read about as expected and show the same nominal 60 to 70°F temperature range for tanks with low heat generation rate. It is also assumed that variations in the headspace temperature in comparison to the regression line formula will cancel out over the period of evaporation calculations.

RPP-RPT-54981, Rev 0, Appendix A, Section A.4 explains the derivation of breathing rate estimates. The breathing rate estimates are based upon extrapolation of results from 13 tracer gas tests made in the 1990s. No breathing rate tests were performed in 20 ft. diameter tanks. Information presented in Appendix A indicates atmospheric pressure variation may not have a major impact on tank breathing rate. See RPP-RPT-54981, Rev 0, Appendix A, for discussion of the assumed breathing rates and extrapolation of the breathing rate test results to 200-series SSTs.

How condensation during a tank breathing process differs from a once-through active ventilation system was estimated conservatively. In an active ventilation system there should be minimal condensation until the ventilated air leaves the tank and is above ground. For a breathing tank it is conservatively assumed that the air leaving the tank headspace and entering the bottom of the breather filter (in the process of leaving the tank), and the ambient air entering the top of the breather filter (in the process of entering the tank) are mixed, and any water vapor remaining at 100% relative humidity for the air mixture is returned to the tank. This assumption should overestimate the quantity of water returned to the tank at higher tank headspace relative humidities, resulting in an underestimation of the tank evaporation rate.

5.2 Liquid Change Rate Variation

The tank liquid loss rate depends upon the following variables:

- Accuracy of ILL or SL data used
- Assumed fraction of a tank surface that is liquid
- Assumed tank waste porosity

The tank ILL and SL data are assumed accurate since the instruments used are routinely calibrated. The most important data attribute is repeatability so that trends can be observed. Sections 4.1.3 and 4.2.3 show the data are acceptable for this purpose.

Variation in the fraction of tank surface that is liquid and the waste porosity are not issues for tanks B-203 and B-204 since the tanks both have a 100% liquid surface.

The liquid change rate estimate is assumed reasonable.

5.3 Headspace Relative Humidity Variation

The assumed current tank headspace relative humidities for tanks B-203 and B-204 are based upon water vapor data from a tank B-202 headspace sample taken in 1996. Since tanks B-203 and B-204 have the same or more liquid than tank B-202 when sampled and have a much smaller headspace volume the assumed relative humidities should be conservative.

6.0 Conclusions

The conclusions from this document are:

1. Based upon Figure 7 the liquid loss rate for tank B-203 can be explained by evaporation.
2. Based upon Figure 15 the liquid loss rate for tank B-204 can be explained by evaporation.

Tanks B-203, B-204, T-203 and T-204 all show similar level decrease rates, are between 2/3 full and full, and have partial or all liquid surfaces. It is apparent that similar conditions in these tanks are resulting in similar loss rates. The volume change rates and evaporation rates in the tanks are similar, and observing the small distance between the top of the liquid and the vent to the atmosphere it is apparent that evaporation is the cause of the decrease in tanks B-203 and B-204.

7.0   References

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